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CONTINUING FLYING TRAINING BY MEANS OF FLIGHT OPERATIONAL QUALITY ASSURANCE PROGRAM

ABSTRACT

The current growth of commercial air transportation challenges both the industry and the operators. In the flight training sector, air forces as well as commercial operators are in search of low cost pilot training programs. Reacting to demands, flying training organisations address the industry to provide them with compact, versatile aircraft while initiating studies on future common civil-military syllabuses. With the growth of air traffic, the licensing of pilots would eventually become a matter of quantity. Though, many are concerned about raising the quality standards of commercial operators by implementing different flight operational quality assurance (FOQA) programs. Flying training organisations should be aware of this trend in order to take full advantage of it.

This paper mainly addresses commercial operators as well as flying training organisations. It focuses on the purpose and elements of FOQA programs. The opening chapter "Unification of Civil and Military Training" outlines a number of relevant trends in pilot formation and subsequent changes in the flight training syllabuses. Follows a liaison paragraph revealing some basic reasons for implementing FOQA programs. The core of the paper consists of FOQA major elements. The end chapter treats some considerations with regard to FOQA implementation topics.

Pilot training has significantly evolved during the last decade. Changing the principles of flying training came along with changing ageing civil and military trainer aircraft. The target market of the pilot formation schools became more and more compact and put accent on commonality and modularity.

UNIFICATION OF CIVIL AND MILITARY TRAINING

The unification of civil and military pilot training programs is not a recent idea. However, it came into light recently since the commonality of NATO aviation systems and the reduction of costs of training syllabuses became solid trends.

On the military side, the issue is to propose a minimum number of different aircraft types and a civilian-like training program (in terms of cost effectivity) to transform a college graduate with little or no previous flight experience into a fighter pilot. The most powerful armed forces of the world have already made steps in that direction: they usually use three different trainer aircraft types for basic, intermediate and advanced flying training.

Commercial pilot training schools usually make use of a three stage flying training program: basic, intermediate and advanced. The demands for each of those stages are progressively different as compared to the military training system.

It seems that the only stage encountering significant commonality of both military and civil syllabuses is the basic level of training. Similar piston engine (VFR) light aircraft are used to initiate students to the basic skills of flight. Instrument training (IFR) is among the few aspects the compared systems have in common at the intermediate level. The more advanced are the training stages, the more different are from each other the military and the civil demands.

MODULAR TRAINING

The modern approach on flying training is modularity. It's been derived from the aircraft design concept of "black box" interchange-ability, that is the aircraft as a system consists of a number of different modules ("boxes") easy to remove and replace. Moreover, each module has a growth potential resulting in an overall growth potential of the aircraft system.

This concept could be used in designing of a common basic/intermediate trainer aircraft for both military and commercial training, as their commonality factor would suggest.

The modularity concept would be suitable to an entire flying training system, not only to aircraft which is part of the training system. A modular flying training system would not only use common types of trainer aircraft, but furthermore extend its polyvalence in order to gain the capability of admitting to syllabus of ab-initio as well as trained private/ commercial/military pilots holding different ratings and licenses. In other words, one would expect from a modular flying training program to have the properties outlined in Figure 1:

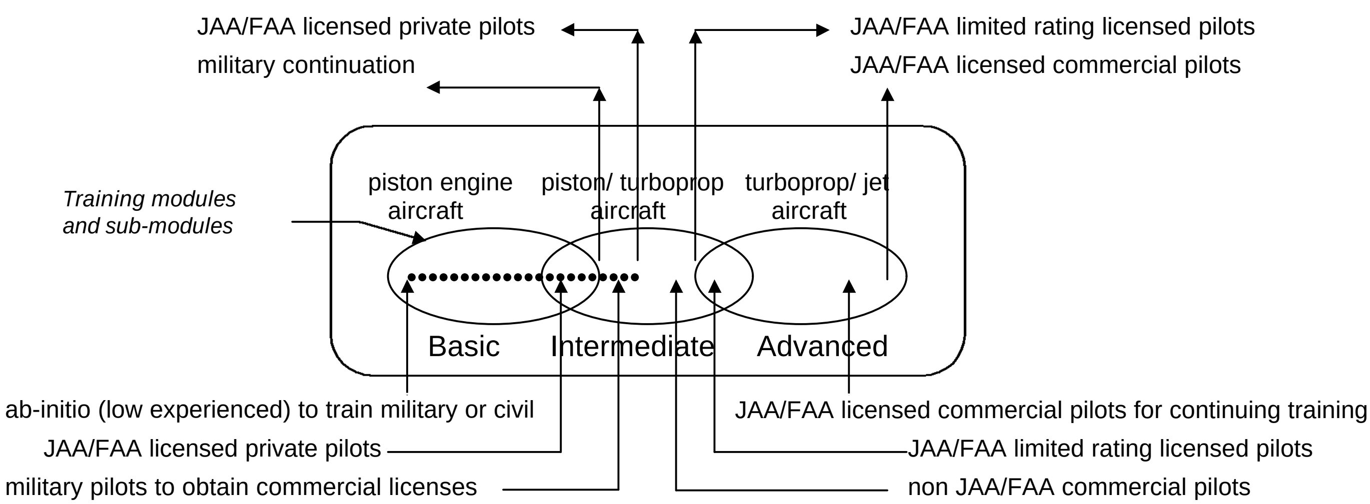

Figure 1: Modular flying training system

Figure 1 shows a complex, modular flying training system scheme consisting of modules and sub-modules. One should notice that a flight training system does not necessarily mean a unique flight training facility, not even a unique organisation. Certain elements of the system could be contracted or sub-contracted on a cost-effectiveness basis. A prime importance should be paid to management structures and departmental scheme of a system, with particular emphasis on quality assurance.

The Joint Aviation Authorities, the European regulatory and control body of civil aviation describe flight operational quality assurance (FOQA) as a major element of the modern operators' policies.

NEED FOR AND PURPOSE OF A FOQA PROGRAM FOR AN AIR OPERATOR

The purpose of a FOQA program is to improve safety by providing more information about, and greater insight into, the total flight operational environment through selective automated recording and analysis of data generated during flight operations. Analysis of data can reveal situations requiring improved operating and training procedures, equipment and supporting infrastructure.

Europe and America are using massive resources to improve flight safety. That is due to the conclusion that, despite of the low catastrophe percentage in the commercial air transportation of about one in a million flights, the significant forecast increase of air traffic threats to increase the number of the victims of air transportation.

A solid FOQA program would have definitely reduced the chances that TAROM's Airbus A310 flight RO371 to Brussels on March 31st, 1995 ended in a terrible catastrophe. Two lessons have been learnt from that accident:

1. The pilots experienced with classic aircraft need particular syllabuses to get familiar with modern automated aircraft based on a very sophisticated electronic technology. Their inhabits, salutary when flying old aircraft, do not favour their shift to new aircraft types and some incline to over-estimate the automation capabilities of modern aircraft;

2. The second remark is related to all categories of pilots: due to financial reasons, a number of air operators put feeble accent on recurrent training of flight crews. That results from the wrong point of view of some commercial operators' managers who often imagine continuing training of flight personnel as ineffective expensive instruction stages that temporarily immobilise valuable human resources.

Some managers ignore the affordable tool for continuing training and flight procedures optimisation offered by the flight operational quality assurance system. Early FOQA programs have been used to gather empirical data about flight crew performance, weather, aircraft design, engine operation and air traffic control for use during accident investigations.

One element that has been missing from that process was quantitative information about operational incidents, which occur more frequently than accidents and are often precursors of accidents. The Joint Aviation Authorities emphasise the role of flight and ground operations quality assurance in the requirements JAR-FCL and JAR-OPS Parts 1-3. The Federal Aviation Administration also recommends by means of the Code of Federal Regulations Part 121 and Advisory Circulars AC-120 series, the implementation of flight operations quality assurance schemes.

Major air operators have already implemented different FOQA programs. They all agree that insights derived from these programs have prevented serious incidents and accidents and have led to improved operating efficiencies. FOQA programs also help to identify and correct deficiencies in flight crew training and operating procedures.

FOQA PROGRAM ELEMENTS

FOQA programs use data provided by the on-board data management systems. These data management systems, initially identified as Aircraft Integrated Data Systems (AIDS), became known as Aicraft Integrated Monitoring Systems (AIMS) when their capabilities expanded to include flight operations data and include the Aircraft Condition Monitoring System (ACMS), Auxiliary Data Acquisition System (ADAS) and Flight Data Acquisition and Management System (FDAMS). Figure 2 shows a typical AIMS configuration.

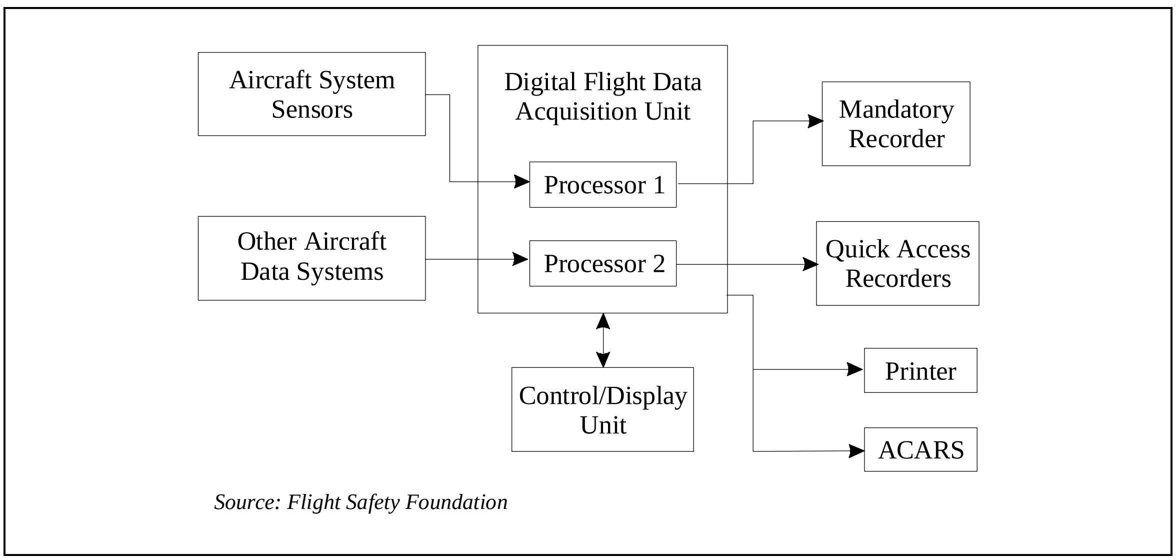

Figure 2: Aircraft Integrated Monitoring System Configuration

A Digital Flight Data Acquisition Unit (DFDAU) aquires and processes the parameter data into a digitised data stream for recording by the Digital Flight Data Recorder (DFDR-mandatory) and a data stream for recording by the most common equipment for storing FOQA data, which is the Quick Access Recorder (QAR- non mandatory). This is done by means of dual independent processors contained within a single unit.

A Control and Display Unit displays or prints maintenance or exceedance reports.
The early QARs contained magnetic tape cartridges or cassettes easy to

remove and replace. Newer optical disk QARs provide expanded storage capacity. Additional data provided by the DFDAU increased the problems regarding the QAR flight-hour capacity. Output data rate to the QAR doubled from the standard 64 words per second to 128 words per second. Users welcomed the improved data rate though it increased the frequency of QAR cassette removals.

A Data Management Unit performs all the functions of an acquisition unit and provides additional advanced on-board processing and expanded operator programming flexibility. Acquiring, analysing and sorting of aircraft systems information and distributing of the results to user-selected devices remain primary functions. After acquiring of selected parameters from multiple data sources, evaluating the data based on user-defined algorithms and detecting the predefined event conditions, the Data Management Unit can either store the selected event information or transmit it to the ground instantaneously by means of a Communication and Reporting System. Data sent and received using a two-way communication digital data link reduces communication errors and decreases the number of required voice transmissions by flight crews, thus enabling them to focus on other duties.

Data compression within the DMU has increased QARs' recording capacity. Data compression requires complex mathematical processing of the variations in a parameter to reduce the volume of the data to be recorded. Most processing algorithms are based on representing a parameter that remains stable for several hours as one data value between two time moments. Such algorithms are to significantly reduce the amount of tape that would be required to record selected parameters for several-hours periods. Figure 3 illustrates the potential data storage savings for an average 12-hours flight, using one manufacturer's data compression method.

FLIGHT DATA COMPRESSION

A. Typical 12 Hour Flight, Non-Compressed

MODE	TIME (MIN)	RATIO	KBYTES
GRD	12	1 : 1	278
TKO	26	1 : 1	602
CRZ	635	1 : 1	14707
LAND	35	1 : 1	811
GRD	12	1 : 1	278
TOTAL	720		16676

B. Same flight Using an Average Compression Ratio of 23 : 1

MODE	TIME (MIN)	RATIO	KBYTES
GRD	12	5 : 1	55.6
TKO	26	2.5 : 1	240.8
CRZ	635	300 : 1	49.0
LAND	35	2.5 : 1	324.4
GRD	12	5 : 1	55.6
TOTAL	720		725.4

Figure 3: Flight Data Compression

Different compression techniques are used in the community but all techniques are subject to increased attention of users in terms of bit errors at compression/decompression.

EVENT CATEGORIES, PARAMETERS AND EXCEEDANCE LEVELS

The term “event category” refers to the classification of an occurrence. Event categories are operational conditions selected for monitoring and review. These conditions include a broad range of aircraft and engine systems characteristics such as system mode status, performance limitations, flight control system inputs and responses, rates of change and relative time of event duration.

From a maintenance perspective, the selection of event categories focuses on system information related to maintenance reliability, manufacturer’s warranties, aircraft and engine performance documentation for operational usage compliance and systems troubleshooting. In contrast, monitoring flight operations focuses almost totally on situational exceedances that vary by phase of flight.

Event categories are generally developed by analysing safety issues in accidents and incidents and postulating the exceedance categories needed to identify these safety issues in an operating fleet. Current event category databases have evolved from those identified by the earliest FOQA users. The events adopted by most users parallel standard training and flight-check syllabuses. Table 1 contains common event categories tracked by existing programs.

EVENT CATEGORIES MONITORED BY MODE OF FLIGHT*			
TAXI MODE EVENTS	CLIMB MODE EVENTS	LANDING MODE EVENTS	GO-AROUND MODE EVENTS
EGT ON ENGINE START	CLIMB THRUST	SPEED HIGH AT TOUCHDOWN	G/A ACTIVATION
NI/EPR ON TAXI	CLIMB EGT	ABNORMAL HIGH PITCH ON ROLLOUT	G/A THRUST
TAXI SPEED	INITIAL CLIMB PITCH RATE	OVERWEIGHT LANDING	
LATERAL ACCELERATION	REDUCED LIFT MARGIN	VERTICAL ACCELERATION: BOUNCE	
	GEAR UP EARLY	VERTICAL ACCELERATION: BOUNCE	
TAKEOFF MODE EVENTS	GEAR UP SELECTED SPEED	SPOILERS LATE TO DEPLOY	
TAKEOFF THRUST SETTING	GEAR UP SPEED	REVERSE THRUST LIMIT(SPO)(PWR)	
EGT ON TAKEOFF		EGT LIMIT	
HORIZONTAL STABILISER SET	APPROACH MODE EVENTS		ALL FLIGHT MODE EVENTS
TAKEOFF ACCELERATION	WIND SHEAR BELOW 1500 FT		EXCESSIVE ROLL RATE
LOW ROTATION RATE	GEAR DOWN LATE		ABNORMAL ELP/BLTCONE
HEADING DEVIATION	SPEEDBRAKE ARM DELAY		FLAP/PLAT ALT LIMIT
TIRE LIMIT SPEED	APPROACH THRUST		REDUCED LIFT MARGIN
ABORT TAKEOFF	LOW POWER ON FINAL		ALPHA PROTECTION
	GROSS POWER INCREASE ON FINAL		
	OVERSHOOT ON APPROACH		
	HEADING CHANGE EXCESSIVE (LOW)		
	APPROACH SPEED HI/LO		
	TAIL WIND LIMIT		
	REVERSERS DEPLOYED IN FLIGHT		
	SPEED DEVIATION AT THRESHOLD		

** LISTED EVENTS ARE COMMON TO > 50% OF SURVEYED OPERATIONS*

Table 1: Most common event categories listed

Parameters are measurable variables that supply information about the condition of a system. Several parameters would generally be necessary to define a single event. For instance, the event called "excessive pitch rate on takeoff rotation" would be defined by a group of parameters like pitch-attitude, time and air-ground sensor.

There are four different types of parameters:

a) Mandatory DFDR parameters;
b) Aircraft manufacturer common designated parameters;
c) New aircraft purchase requested parameters;
d) Operating fleet modified parameters.

Groups b), c) and d) are not Authority mandatory, they are voluntary FOQA data. Table 2 outlines some of the common parameters typically used for event categories:

TYPICAL PARAMETERS UTILISED FOR COMMON EVENT CATEGORIES			
LIMIT MONITORED EVENT CATEGORIES	PARAMETERS USED TO ESTABLISH EVENT OCCURRENCES FOR SPECIFIC FLIGHT MODES		
	TAKEOFF MODE	CLIMB MODE	CRUISE MODE
NORMAL ACCELERATION LIMIT	NORMAL ACCELERATION AIR GROUND LOGIC	NORMAL ACCELERATION FLAP POSITION AIR GROUND LOGIC	(SAME AS CLIMB)
ROTATION RATE HIGH	PITCH ATTITUDE RELATIVE TIME AIR GROUND LOGIC	———	———
UNSTICK SPEED HI/LOW	COMPUTED AIRSPEED AIR GROUND LOGIC	———	———
ABORT TAKEOFF	COMPUTED AIRSPEED **ENGINE THRUST**	———	———
GEAR UP SPEED	———	COMPUTED AIRSPEED GEAR IN TRANSIT	———
EARLY FLAT/SLAT CHANGE	———	ALTITUDE COMPUTED AIRSPEED FLAT/SLAT POSITION AIR GROUND LOGIC	———
Vmo EXCEEDANCE	———	BARO ALTITUDE COMPUTED AIRSPEED	BARO ALTITUDE COMPUTED AIRSPEED
Mmo EXCEEDANCE	———	BARO ALTITUDE MACH SPEED	BARO ALTITUDE MACH SPEED
MAX OPERATING ALT	———	———	BARO ALTITUDE
STICK SHAKER	STALL WARNING	STALL WARNING	STALL WARNING
GPWS OPERATION	GPWS WARNING	GPWS WARNING	GPWS WARNING

Table 2: Common parameters used in current programs (examples)

COLLECTION AND RETRIEVAL OF DATA

Because of the limited data storage capability, FOQA users either choose to record raw data in flight and to process the data using a ground replay station for event exceedance analysis, or adopt a method to perform real-time in-flight analysis of the events and record data only when an exceedance occurs. Both methods have merit. Both have disadvantages. Thus, selective data recording appears to be cost-effective in terms of diskettes replacement rate. It ignores routine operations but has the disadvantage of losing expanded pre-event and post-event information that might be useful for complete understanding of some events. Raw-data recording requires most users to use data compression or/and to intermittently record parameters during stable flight (cruise). Only the critical phases of flight are fully recorded: takeoff, initial climb, approach and landing (see Figure 4).

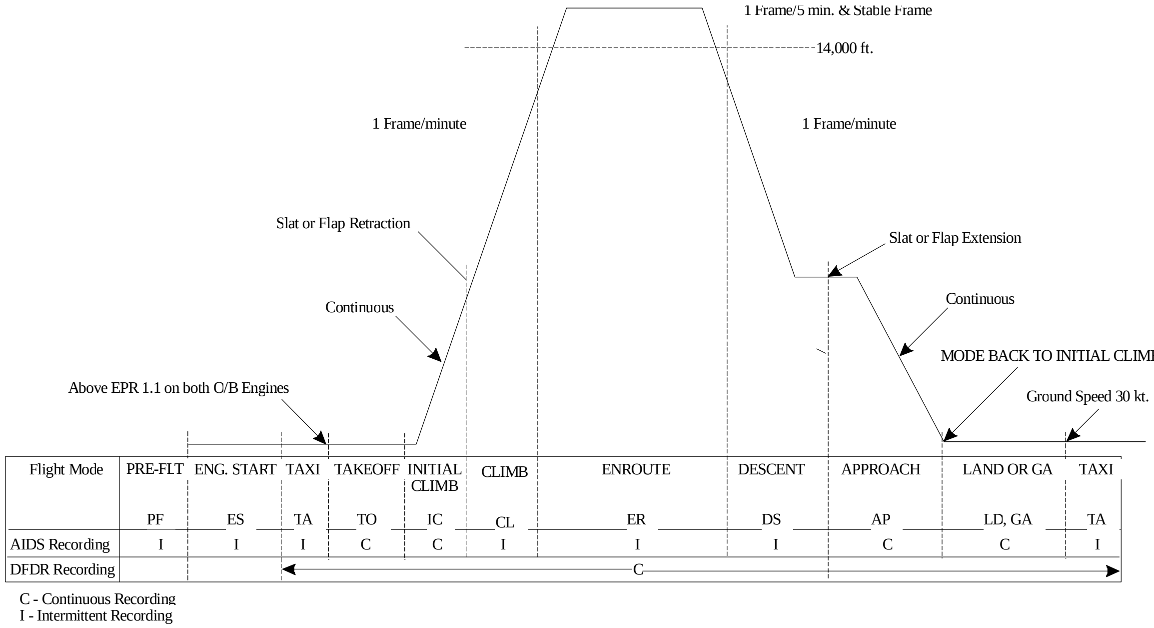

Figure 4: Typical Phase of Flight Recording Cycle

FOQA IMPLEMENTATION CONSIDERATIONS

The cost of implementing a FOQA program largely varies depending upon an operator's needs. As it has been described, a large palette of subsequent choices is available. Some poor operators choose not to implement it at all, given its non-mandatory status.

However, besides their safety enforcement character, operational quality assurance programs prove to be effective tools to be used in cutting costs derived from operations. Some of the arguments to back this conclusion would be:

- the optimisation of operational procedures through continuing survey;
- the implementation and optimisation of preventive maintenance of aircraft in terms of components replacement rate by means of condition monitoring of components performance;
- the optimisation of flight crew performance.

One should also notice the increase of the intangible assets of an operator whose brand would have the "quality assurance" mark over it.

Because of the potential of FOQA programs, there were established "body of knowledge" centres known to give counselling on operational quality issues and implementation of programs. Among them, the Air Transport Association (ATA)'s Aviation Safety Committee and the ARINC-DFDR Committee. Major international operators addressed them to collaborate in customising operations quality programs.

Flying training organisations would also make use of FOQA issues in two ways:

- by implementing FOQA schemes to their own structures, procedures and syllabuses;
- by constituting themselves as advisory&assistance bodies.

The modern approach on quality assurance in aviation has definitely shifted from the old fashioned periodical review of past events to anticipating of trends by continuing monitoring of systems. More and more organisations plan to size and implement operational quality systems. Would that be a challenge for the next decades?

Bibliographic resources:

1. *JAR-FCL "Flight Crew Licensing" ;*
2. *JAR-OPS "Commercial Air Transportation,*
3. *CFR Part 121 "Operating Requirements"*
4. *FAA Draft Advisory Circular "FOQA Program"*